Technical Note
TN 00-4

(DTIC # qq-qqqq qqq)

INJURY CONTROL PART II: STRATEGIES FOR PREVENTION

Prepared by

Nicole S. Bell, ScD, MPH
Paul J. Amoroso, MD, MPH
Susan P. Baker, MPH, ScD (hon)
Laura Senier, BA

January 1999

Military Performance Division
U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2000	Technical Note

4. TITLE AND SUBTITLE

Injury Control Part II: Strategies for Prevention

5. FUNDING NUMBERS

6. AUTHOR(S)

N.S. Bell, P.J. Amoroso, S.P. Baker and L. Senier

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

US Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

8. PERFORMING ORGANIZATION REPORT NUMBER

TN00-4

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

US. Army Medical Research and Materiel Command
Fort Detrick, MD 21702-5012

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Epidemiology has made significant contributions to the improvement of human health by reducing the burden of acute infectious and chronic diseases. This report applies epidemiologic methods to injury prevention. We review two methodological approaches that can be used to prevent injury. Passive methods modify the environment so that individuals are protected from injury without having to take any additional precautions. In contrast, active strategies require an individual to take action in order to reap the benefit of reduced injury morbidity or mortality. This report reviews various health psychology theories and approaches and two conceptual tools for developing injury control interventions: the Haddon matrix and Haddon's ten strategies. We discuss the management of injuries in the field, and factors that render medical care services optimally useful in reducing morbidity and mortality once an injury has occurred. These factors include availability, accessibility, accommodation, affordability, and acceptability of medical care services. A companion report, "Injury Control Part I: Understanding Injuries in the Military Environment," describes the scope of the injury problem in the military; defines injury; reviews several different methods of classifying injury; and reviews the types of hazards that threaten the health and safety of soldiers, both in wartime and peacetime.

14. SUBJECT TERMS

injury, prevention, health promotion programs, health psychology, Haddon matrix, TAIHOD, Army, military, epidemiology, Haddon's ten strategies, database

15. NUMBER OF PAGES

47

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

CONTENTS

List of Figures v

Acknowledgements vii

Executive Summary 1

Injury Control in the Military 3
- The Epidemiologic Triangle 3
  - Host Factors 5
  - Environmental Factors 5
  - Vehicles, Vectors, and Equipment 6
  - Agents 7
- Intervention Strategies: Different Approaches 7
- Unintended Consequences and Risk Compensation 8
- Strategies for Planning Injury Prevention Programs 9
  - The Haddon Matrix: Identifying Injury Intervention Opportunities 9
- Haddon's 10 Strategies for Control of Hazards of All Types 14
- Passive Intervention Strategies 23
- Active Intervention Strategies 24
  - The Health Belief Model 26
  - Health Locus of Control 27
  - Social Learning Theory 27
  - Theory of Reasoned Action 27
  - Stage Models 28
  - Social Contagion Model 29
- Management of Injuries in the Field and Access to Care 30
  - Short-range Management of Injury 31
  - Medium-range Management of Injury 31
  - Long-range Management of Injury 32

Conclusion 33

References 34

LIST OF FIGURES

Figure		Page
1	Navy Rates of Aviation Fatalities, 1949-1995	3
2	The Epidemiologic Triangle	4
3	William Haddon, Jr., MD	6
4	The Haddon Matrix	9
5	Airbag Efficacy	12
6	Haddon Matrix of Interventions to Reduce Wartime Motor-Vehicle Crashes	13
7	Weather Watchers Give Parachute Training the "All Clear"	14
8	Destruction of Anti-Personnel Mines	15
9a & 9b	Crashworthy Fuel Systems	16
10	Parachute Landing Fall	17
11	EVA Spacewalk	18
12	Protective Gear	19
13	Designed to Crash	20
14	Training Exercises	21
15	After Tragedy, Relief in Oklahoma City	22
16	MEDEVAC Helicopter	23

ACKNOWLEDGEMENTS

This report was derived in part from the chapter "Injury Control," in the *Textbook of Military Medicine: Medical Aspects of Deployments to Harsh Environments* (Washington, DC: U.S. Department of the Army and the Borden Institute, In press).

This work was supported in part by funding from the Defense Women's Health Research Program (Army Medical Research and Materiel Command; #W4168044) and from the National Institute on Alcohol Abuse and Alcoholism (#1 R29 AA11407-01A1 and #R29AA07700). The contents herein are the sole responsibility of the authors and do not necessarily represent the position or the policy of the U.S. Army, the Department of Defense, or the National Institute on Alcohol Abuse and Alcoholism. No official endorsement should be inferred.

The authors would like to thank the following individuals for their assistance in preparing this technical report:

Shari Hallas for editing the report.

MAJ Joseph Creedon, PA, PhD, USARIEM, and Dr. Karen Kuhlthau, Ph.D., Associate Director, General Pediatric Research Unit, Massachusetts General Hospital, for their critical reading and comments on the manuscript.

EXECUTIVE SUMMARY

As a science, epidemiology has made significant contributions to the improvement of human health. The application of quantitative and scientific method to the study of the spread of human disease has led to reductions in morbidity and mortality from cardiovascular disease, cancer, and infectious disease. Through studies of associations and risk factors we have learned about the risks and hazards associated with exposures to toxic waste and dangerous products. Recently, the principles of epidemiologic inquiry have been applied to reducing the burden of injury morbidity and mortality.

This report applies the traditional, triangular epidemiologic framework to the field of injury epidemiology and prevention. In this framework, injury is viewed as a result of the interaction of a human being with his or her environment and the source of injury-causing energy. By adapting the standard epidemiologic triangle (which is commonly used to understand diseases caused by infectious agents or pathologic processes), we see that the key to improving injury mortality is to disrupt the sequence of events that normally leads to an injury.

The report reviews two separate methodological approaches by which we can intervene in the injury process. Passive methods, pioneered by William Haddon in the 1950s and 1960s, typically modify the environment so that individuals are protected from injury without having to take any additional precautions. The field of injury prevention is filled with examples of this approach, from the improved design of roadways and guardrails to the formulation of household cleaning agents to the installation of fire sprinkler systems in residences. Measures such as these have already resulted in significant reductions in mortality from motor-vehicle injuries, poisonings, and smoke- and fire-related deaths.

In contrast, active strategies require an individual to take repeated actions in order to reap the benefit of improved health, or reduced injury morbidity or mortality. An example of an active strategy is a campaign to get drivers to wear seat belts. This report reviews the various health psychology theories and approaches that can be applied to initiate and maintain the adoption of injury-prevention campaigns.

This report also reviews two important conceptual tools for developing such injury control interventions: the Haddon matrix and Haddon's ten strategies.

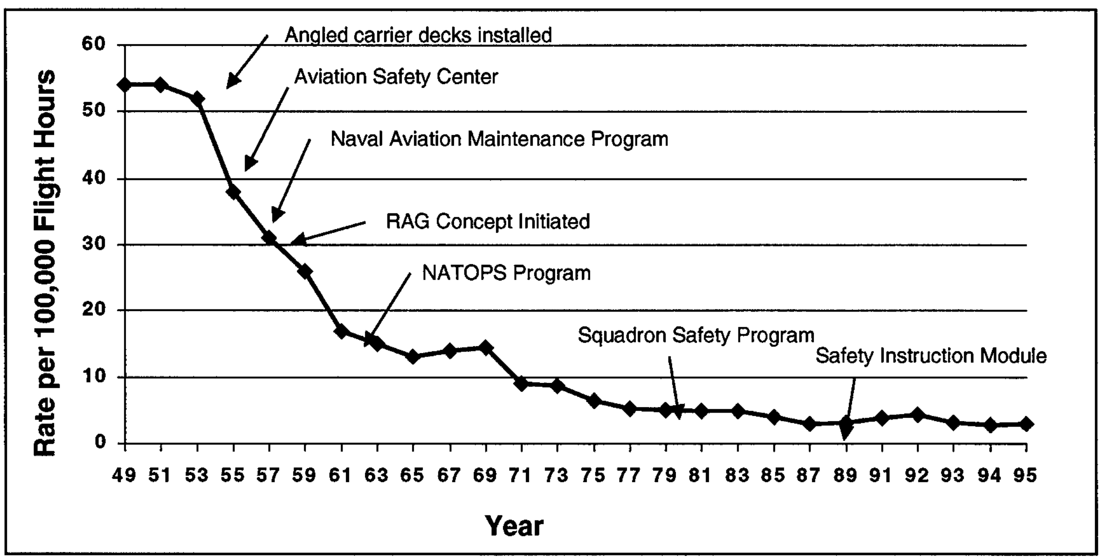
Finally, this report discusses the management of injuries in the field, and the factors that will render medical care services optimally useful in reducing morbidity and mortality once an injury has occurred. These factors include availability, accessibility, accommodation, affordability, and acceptability of medical care services. The most effective strategies for reducing the burden of injury will take into account the need to deliver medical care services promptly to people suffering the acute effects of an injury, but also to plan for their mid-range medical needs and their long-term rehabilitative needs.

A companion report, *Injury Control Part I: Understanding Injuries in the Military Environment (13)*, describes the scope of the injury problem in the military; defines injury; reviews several different methods of classifying injury; and reviews the types of hazards that threaten the health and safety of soldiers, both in wartime and peacetime.

INJURY CONTROL IN THE MILITARY

The history of the armed forces provides countless examples of injury control successes. Safety programs and injury prevention initiatives have resulted in the remarkable reduction of aircraft crashes, the near elimination of fires after crashes of helicopters, and a dramatic reduction in parachuting injuries over the past several decades. No single factor can be cited as the reason for these successes. Only through multi-disciplinary approaches can injury reduction of this magnitude be accomplished. Cooperation and collaboration of medical, safety, command, legal, engineering, and behavioral scientists are necessary to obtain true success in injury control. Yet fatalistic attitudes still prevail, embodied in the notion that there will always be some injuries we are powerless to prevent. While we will never completely eradicate injury, Class A aviation crashes did not appear any more preventable decades ago when rates were over 100 per 100,000 flying hours than now when they are only 1.5 per 100,000 flying hours (29). Figure 1 illustrates Navy aviation fatality rates, demonstrating the temporal association between a number of injury-prevention interventions and the trend line.

Figure 1. Navy Rates of Aviation Fatalities, 1949-1995

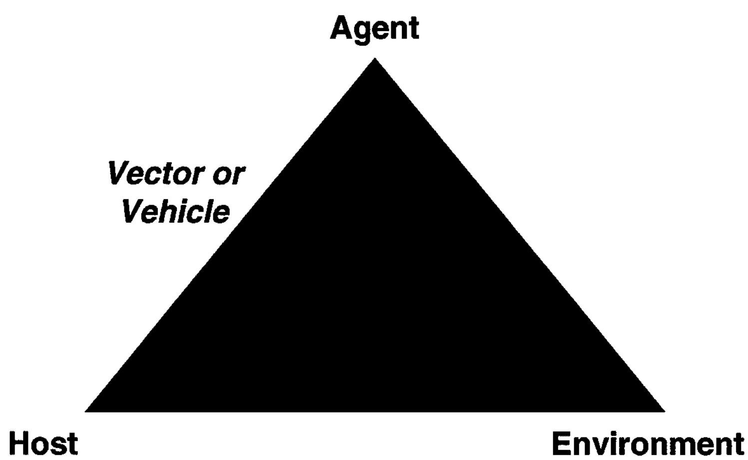


This graph demonstrates that Class A aviation accidents have dropped precipitously over the past 50 years. The steepest declines have happened concurrently with the implementation of accident-prevention initiatives, beginning with the angling of carrier decks in the mid-1950s. Source: Naval Safety Center. RAG = Replacement Air Group (now Fleet Replacement Squadron); NATOPS = Naval Air Technical Operating Procedures.

THE EPIDEMIOLOGIC TRIANGLE

Injury results from a transfer of energy to an individual that is above or below the levels of tolerance of human tissue. The key to injury control lies in modifying the injury-causing agent (energy), individual behavior, the environment, or the way each of these factors interacts with the others. The goal is to interrupt the normal injury causing sequence of events. It is not always necessary to prevent the transfer of energy entirely; sometimes a change in the interaction of the person and the energy can bring the energy transfer within the limits of human tolerance. A traditional epidemiologic agent-host-environment model is sometimes used to describe this process (see Figure 2).

Figure 2. The epidemiologic triangle



This model is often used when studying infectious diseases and identifying intervention opportunities. In the infectious disease model, these elements include the agent (or disease pathogen), the host (the human suffering from or at risk from the infectious agent), the environment (taken broadly to include both the physical and sociocultural milieu that may contribute to the infection) and the vehicle or vector that carries the agent to the host. If the infectious disease under discussion is malaria, for example, the agent might be the parasite *Plasmodium falciparum*, and the host is the human. Malaria is transmitted by mosquitoes that, as living creatures, are considered vectors. To prevent malarial infections, we should examine each element in this triangle and consider the intervention options we might apply to each. We might choose to address the agent itself. For example, a chemical could be developed and distributed (e.g., aerial spraying) that alters the plasmodium in such a way as to disrupt its reproductive capabilities. Alternatively, or in addition, we could focus on the host and try to build up host resistance through inoculation. (E.g., in the past people were given quinine as a prophylactic agent against malaria.) We could also try to prevent host contamination by eliminating the vectors. For example, we could introduce bats to reduce the mosquito population. We could also make changes in the physical environment by eliminating stagnant water where mosquitoes tend to breed. Environmental change should be viewed broadly to also include normative behavior changes, such as teaching people to not wash clothes or bathe in sluggish water where mosquitoes breed. It might also include encouraging the use of mosquito netting or repellents, or fostering an environment where it is socially acceptable, even macho, to protect oneself.

The epidemiologic triangle can also be used to identify strategies to prevent or reduce harm from injury. In injury control, it is energy that is the agent of concern, rather than a disease pathogen. Most commonly, mechanical energy is the culprit. The host is, again, the human. The environment, as with infectious disease interventions, includes both the physical and broader socioeconomic and cultural environments, including command-level influences. As with disease, in injury control we need to think about vehicles and vectors that transmit the unwanted energy to the host. These are usually inanimate vehicles such as electric power lines or motorcycles. However, in some cases the energy carrier is a living creature—as in human assaults or dog bites—and in these cases the energy carrier is correctly called a vector. Each of these elements is discussed in more detail below.

Host Factors

Host factors are characteristics that predispose an individual either to experience a transfer of energy, or to be more susceptible to tissue damage given the occurrence of such an event. These intrinsic factors might include an individual's age; gender; race; anthropometric characteristics such as height, weight, and muscle mass; and behavioral factors such as the propensity to use or abuse alcohol or drugs or engage in other high-risk activities. Some acquired individual factors that might place active-duty personnel at risk include sleep, diet, general nutrition, immunization status, and stress. Deploying to new environments often involves traversing several time zones, losing contact with friends and family, and the need to cope with the uncertainty of survival in a war zone. All of these factors combine to create substantial stress, which in turn may contribute to poorer cognitive functioning (and thus increased risk for exposure to injury) or poorer response and recovery from an injury. Certain host behaviors (e.g., risk-taking behaviors, use of alcohol, smoking status) have been associated with an increased risk for experiencing an injury event, (4, 6-8, 11, 16-18, 20, 24, 25, 28, 30, 31, 37, 39, 40, 54, 57, 59, 60, 65, 66, 70, 72, 73, 77-79) increased severity of injury, or the ability to survive and recover from the injury event once it has occurred (9, 23, 41, 45, 46, 49, 52, 56, 71, 74, 76, 80).

Environmental Factors

There are certain environmental physical factors and structural conditions that may encourage, or at least not inhibit, the unwanted transfer of energy. These might include driving over unfamiliar terrain or parachuting onto a hard surface as opposed to more forgiving ground (5, 36, 44, 50). Sociocultural environmental factors include attitudes about risk taking and health, such as beliefs about wearing a safety belt and awareness of or beliefs about the risks of consuming alcohol before or while operating a motor vehicle. Sociocultural factors also include community and command-level attitudes and support of safety-related issues. The example set by officers and others in command sets a precedent for the behavior of subordinates. Community opinions about drinking and driving, and community support of emergency medical systems (EMS) are both examples of sociocultural and socioeconomic factors related to injury. Police presence, cultural acceptance of violence, and the presence of safety-related laws are also examples of environmental factors. For example, most bases require gun owners who live in the barracks to register and lock up their weapons in a secure, centralized location, usually the unit arms room. Because this makes it difficult to obtain the weapon, the result could be significant reduction in intentional and unintentional firearm injuries resulting from impulsive actions. On the other hand, the inconvenience of obtaining the weapon when it is needed may give soldiers the incentive to find other places to store the weapons, such as in the glove compartment of their car, or at a friend's house. We will discuss unintended consequences further in the section on active and passive strategies.

Vehicles, Vectors, and Equipment

Design characteristics of vehicles and equipment have a great potential to either mitigate or cause injuries. Some of the greatest advances in injury prevention have been achieved through modification of vehicles or equipment. For example, helicopters are now equipped with breakaway or collapsible control sticks, thereby reducing the risk of impaling the pilot during a crash. Many helicopters now have airbags as well. Perhaps the most substantial advancements in motor vehicle safety have been attained by the re-engineering of automobiles and roadways. The introduction of shatterproof windshields has saved hundreds of lives and prevented thousands of disfiguring injuries (55). At one time, street signs and utility poles were grounded in cement and placed close to the edge of the roadway. If a motorist crashed into and damaged one of these poles the response of the utility companies was to replace it with a sturdier one that would be less likely to give way in a subsequent crash. At the time, this probably made sense to the utility companies, but this made the street signs and utility poles into greater hazards to motorists. Finally, thanks in large part to the pioneering efforts of safety advocates such as William Haddon, Jr., the danger of these unyielding signs was highlighted. Dr. Haddon was one of the first to point out the fact that even usually safe motorists make mistakes, and that sometimes these mistakes culminate in a collision with a street sign. Momentary lapses in judgement or reactions to unforeseen situations, such as a child or animal dashing in front of the car, needn't be punished

Figure 3. William Haddon, Jr., MD

Trained as a physician and an engineer, Haddon is considered the founding father of the modern-day injury prevention movement. He is responsible for developing two conceptual frameworks that are important in the design of injury-control measures: the Haddon matrix and the ten strategies. (Photo courtesy of Susan Baker.)

with death. Making the street signs more forgiving through breakaway designs, or creating obstacle-free safe zones along our highways allows motorists who veer off the roadway to avoid devastating or fatal injury.

Agents

Energy transfer, most commonly the transfer of mechanical energy, causes injuries. The development of intervention strategies should incorporate approaches to modify the energy transfer in such a way as to prevent the release of the energy or reduce the amount of energy that may be released. Safety mechanisms on guns, for example, reduce the chance that the gun will be unintentionally fired. Bulletproof vests and Kevlar helmets change the character of the energy an individual experiences when hit by a bullet or shrapnel. Efforts to prohibit the use of land mines by the world community are another current example (3).

INTERVENTION STRATEGIES: DIFFERENT APPROACHES

Active strategies are interventions that require an individual to make a conscious decision to behave repeatedly in a certain way (such as choosing to put on a seatbelt). Passive strategies do not require a specific change in a person's behavior in order to be effective. While each approach has merit, each also has limitations. Most members of the injury control community agree on the virtues of both passive and active approaches to injury prevention, but there is often considerable debate over the specific implementation of various active and passive countermeasures.

Active strategies require the individual to make decisions regarding his or her health. Such approaches are usually less intrusive on personal liberties and often, if successful, less expensive than engineering approaches, though the cost per success may be high. On the downside, some people will never change their behavior, and all of us are subject to momentary lapses in attention or judgement. In fact, those who are at greatest risk of injury because of risk-taking habits are often among those least likely to alter their behavior (43). In addition, some of us fall unfortunate victims to the behavioral transgressions of others — often the result of actions entirely beyond our individual control. Behavior change requires maintenance and tends to erode over time as education campaigns end or lose their novelty. Moreover, active strategies require that a person possess a specific skill or level of cognitive functioning in order to be effective. Thus individuals with a cognitive deficit (e.g., someone who is injured, sleep deprived, in an extremely fearful state, or who has used alcohol or medication) may be unable to perform a safety procedure effectively. Most importantly, active strategies ignore the potential for human error. No matter how many times a person rehearses a specific skill there will always be the potential for a small mistake. The question, then, is should the price for a momentary lapse in judgement, or a small slip-up, be death?

Passive strategies provide automatic protection, as in the case of padded dashboards and household fuses. They have a distinct advantage over active strategies when it comes to accounting for the human error potential. Passive strategies cover all members of a population, even those who take great risks or who are temporarily or permanently impaired. They do not erode over time and do not require any specific set of skills for an individual to be protected. Nor do they require an action each time someone is to be protected. They are generally the most effective. On the downside, some may be viewed as intrusive on personal liberties and some are expensive. Distribution of the costs for these interventions may be a contentious issue as well.

Clearly there are strengths and limits to both active and passive approaches. A comprehensive injury control program capitalizes on the most effective measures (usually passive) while also incorporating strategies to change the behavior of individuals—consumers, manufacturers, and legislators whose decisions ultimately affect the risk of injuries to others.

UNINTENDED CONSEQUENCES AND RISK COMPENSATION

Injury interventionists must be concerned not only with the prevention of injury through appropriate intervention, but also with the potential for unintended consequences. Knowledge that a safety device is in place has the potential to change an individual's or an organization's behavior. Economists refer to this idea as risk compensation, although this idea is not universally accepted in injury control circles. In essence, risk compensation is said to occur when an individual takes additional risks that he or she may have been unwilling to take in the absence of the safety device or intervention. For example, a person driving a car with an airbag may be less likely to fasten their seat belt. Insurance may also cause people to be less careful if they believe they are less susceptible to financial consequences of a disaster. For example, people may be more likely to build or purchase a house near a floodplain if they have been able to purchase flood insurance. Finally, boxing gloves allow boxers to exchange blows for longer periods of time. While each punch may seem to be less injurious (because of the padding afforded by the gloves), the cumulative effect of sustaining repeated blows to the head may still result in long-term neurological consequences or even death.

Risk compensation may also be used to the advantage of safety by increasing the perceived riskiness of an activity. For example, speed bumps in roadways actually *increase* risk of injury and damage to the vehicle. Driving quickly over a speed bump may cause damage to the vehicle or could cause the driver to lose control of the car. It is also uncomfortable for occupants to go quickly over a speed bump. The combination of these factors ensures that most drivers will slow down when approaching a speed bump. In parks, residential areas and near schools, the net effect of this is to make the roads safer for all.

In some cases the trade-offs in terms of risks and benefits associated with an intervention are not easy to evaluate. For example, air bags have saved over 2,000 lives, but have also been implicated or involved in the deaths of dozens of people, mostly children (2, 38). There are reported cases of children being strangled when their scarves or jacket drawstrings are caught in the drain holes found at the top of some playground slides—placed there initially in order to prevent slip-and-fall related injuries. Injury interventions must be continuously evaluated not only with respect to their efficacy in preventing the target injury, but also with respect to these unintended consequences. As long as proper evaluation research is conducted, unintended consequences can be addressed. The challenge is to do so before the soldiers or the public take it upon themselves to thwart the intervention (refusing the vaccine, disarming the airbag).

STRATEGIES FOR PLANNING INJURY PREVENTION PROGRAMS

Injury prevention has been considered an important component of the medical arts since the time of Hippocrates, but was not systematized until the mid-twentieth century through the efforts of injury-control pioneers such as William Haddon, Jr., MD. Dr. Haddon is credited with two widely accepted tools related to the prevention and control of injuries. The first of these tools is known as the Haddon matrix, which provides a conceptual framework for strategizing approaches that target the host, agent, and environment at different phases of the injury-producing event. The second tool is a set of prevention strategies known in the injury control field as the "10 strategies." The 10 strategies provide a scientific approach to injury control, and when coupled with the Haddon matrix, provide an extremely useful methodology for the control of injury hazards of all kinds (32, 33).

The Haddon Matrix: Identifying Injury Intervention Opportunities

All elements of the injury epidemiologic triangle are incorporated in a deceptively simple tool known as the Haddon matrix, shown in Figure 4 (1). The matrix plots the elements of the epidemiologic triangle against another dimension that is important in the development of injury prevention strategies—time.

Figure 4. The Haddon Matrix

	Factors		
Phases	Human	Vehicle/Equipment	Environment
pre-event			
event			
post-event			

The Haddon matrix is essentially a brainstorming tool. It facilitates the careful evaluation of all options available to prevent or reduce harm resulting from a specific injury event. Haddon noted that there were three different stages to the injury process: a pre-event phase when the energy transfer has not yet occurred; an event phase, or the actual point at which energy is transferred to the host; and a post-event phase after the incident has occurred. There are different intervention strategies that can be applied in each of these phases and that correspond to each element of the injury epidemiologic triangle. Haddon proposed that it is often necessary to implement several different interventions to effectively control injuries. As with attempts to control infectious agents, the goal should be to identify the weakest link and apply appropriate intervention strategies (58).

The Haddon matrix, as it was initially developed, was intended for use as a tool to identify ways to reduce injuries and their sequelae. Some researchers who have used the Haddon matrix have incorrectly related the individual rows directly to primary, secondary, and tertiary prevention approaches (51). Dr. Haddon, however, did not agree with this interpretation. In fact, he proposed the three-phase model because the primary/secondary/tertiary model did not fit injury well, since primary prevention strategies could be applied in the pre-event phase, the event phase, and to a limited degree even in the post-event phase (35).

The Haddon matrix can be used to identify options for preventing or reducing harm in each phase of the injury event and for each element of the injury epidemiology triangle. Each cell of the matrix contains a list of the ideas for injury-prevention strategies that apply to that stage. For example, the first row of the matrix includes strategies that attempt to prevent the event from occurring. Examples of interventions that might fit in this row would include combat survival training, education about not rocking soda machines, pilot training and re-qualification, flight checklists, and military aircraft/vehicle maintenance programs.

The second row of the matrix includes strategies that attempt to modify the individual, environment, or protective equipment to reduce or eliminate energy transfer in order to prevent injury altogether, or minimize tissue damage when an energy transfer occurs. Examples of interventions in this row might include required use of safety belts, helmets, life jackets, flak vests, parachute ankle braces, crashworthy fuel systems, and breakaway sticks in helicopters. Note that none of these interventions would prevent the energy transfer event from occurring (i.e., the plane or car would still crash), but they might prevent the individual from being hurt during that event.

Most injury-control efforts tend to focus on the first and second row, because it is optimal to prevent or reduce the severity of the injury altogether if possible. Irving Zola captured the essence and importance of prevention quite well when he said,

> *You know, sometimes it feels like this. There I am standing by the shore of a swiftly flowing river and I hear the cry of a drowning man. So I jump into the river, put my arm around him, pull him to shore and apply artificial respiration. Just when he begins to breathe, there is another cry for help. So I jump into the river, reach him, pull him to shore, apply artificial respiration, and then just as he begins to breathe, another cry for help. So back into the river*

again, reaching, pulling, applying, breathing and then another yell. Again and again, without end, goes the sequence. You know, I am so busy jumping in, pulling them to shore, applying artificial respiration, that I have no time to see who the hell is upstream pushing them all in (53).

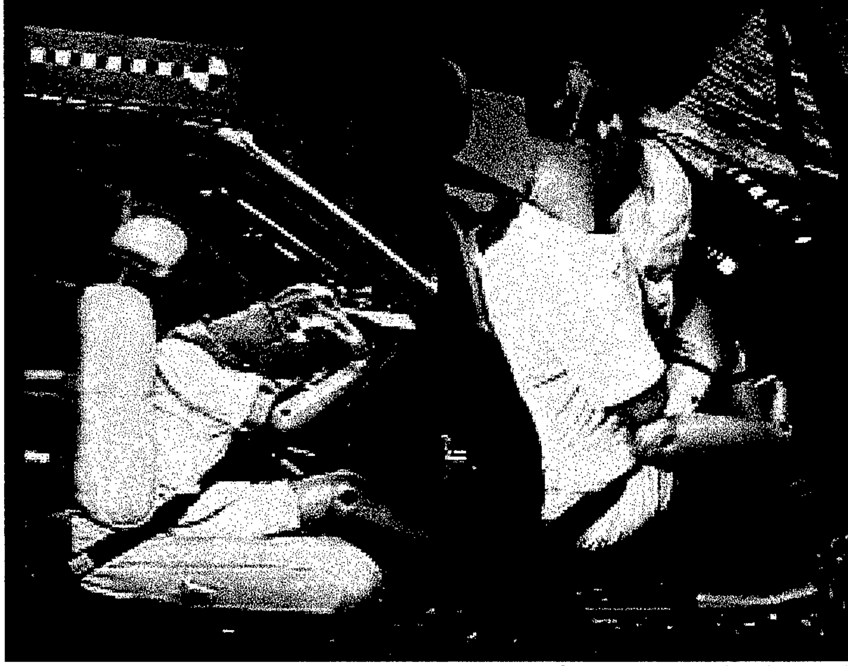
One approach to solving the problem of injury morbidity and mortality is to stand on the riverbank and try to pull people out as they float by. But a better approach may be to go upstream and see what can be done to stop them from jumping in or being thrown in the water in the first place. Because some will inevitably end up in the river, however, it is worthwhile to consider interventions that would be placed in the third row—those that influence the long-term sequelae of injuries once they have occurred and prevent re-injury or injuries that occur subsequent to the initial injury event. Strategies that fit in this row include field-hospital readiness and access, secured runways for MEDEVAC, and training all soldiers in basic first aid and CPR.

Columns of the Haddon matrix correlate to the elements of the injury epidemiologic triangle. The first column includes all intervention strategies that relate directly to host behavior or susceptibility to injury and attempts to modify these factors. Such interventions might include improving physical fitness and training, and providing good reconnaissance information about terrain. The second column focuses on changes in the vehicle (that carries energy to the person) and protective equipment (e.g., airbags, seatbelts, helmets, ankle braces). The third column focuses on modifications to the physical and broader social environmental (e.g., better lighting, better roadways, system support of medical evacuations and disaster preparedness, norms and laws against driving while impaired, policing and enforcing safe behaviors).

The easiest way to understand and begin using this tool is by example. Consider injuries occurring to occupants of motor vehicles (e.g., trucks) during wartime. To control these types of injuries, we will attempt to identify strategies within each cell of the matrix (see Figure 4). The first cell should inspire thoughts of interventions to improve human performance while driving. For example, driver training, adequate sleep, avoiding use of alcohol or tobacco, and accurate knowledge of driving terrain and hazards. The event phase for human interventions would include using safety belts or other protective gear (e.g., gloves, helmets); avoiding alcohol, drug, and tobacco use; maintaining physical fitness; and being experienced and well trained. Some interventions may be appropriate in more than one cell. For example, use of alcohol, drugs, and tobacco may both precipitate the event that leads to energy transfer by impairing performance or by distracting the driver and may reduce the driver's ability to take evasive action. For example, a lit cigarette falling in one's lap is bound to be cause for a bit of excitement and will almost certainly provide at least a momentary distraction from driving. Avoiding tobacco and alcohol may also be relevant to interventions for the third cell in the human column—post-event strategies. Some research suggests that alcohol and tobacco impede tissue-repair processes and thus may prolong rehabilitation or contribute to adverse sequelae (6). Other interventions that would fit in this third cell might include awareness of first aid and general physical fitness to withstand the injury event.

Pre-event interventions in the second column (vehicle and equipment factors) include vehicle attributes such as good working brakes and lights; appropriate design to avoid loss of control or stability (e.g., roll over); and good tires. Event-phase vehicular

Figure 5. Airbag efficacy



These photos demonstrate the effectiveness of an airbag in protecting a driver from injury during a low-speed (35mph) crash. The figure in the driver's seat represents a 5'0" female. Although the seat belt alone will prevent her from being ejected from the vehicle (as shown in the photo on the left), she could still sustain serious injury or facial disfigurement from the impact with the steering wheel or lacerations from a shattering windshield. An airbag is a good example of an intervention that belongs in the equipment factor/event phase cell of the Haddon matrix. (Photo courtesy of the Insurance Institute for Highway Safety.)

strategies might include the presence of an air bag in the vehicle (not preventing the crash from occurring, but possibly reducing or preventing the unwanted transfer of energy to the vehicle occupant); energy-absorbing steering column; roll bars; and side-impact protection. Post-event interventions might include flame-retardant liners in the gas tank or as part of the vehicle interior, and well-maintained and available first aid equipment, phone or radio communication systems, and fire extinguishers.

Pre-event strategies in the third column should target social and physical environmental factors. Troops would need to be prepared to respond to variations in terrain, road and weather conditions, visibility, and enemy position and disposition. Modifications could be made to enhance the accuracy and support of reconnaissance team, strengthen command support and enforcement for driver training programs and alcohol and drug detection and treatment programs; and command support of smoking cessation programs. Event-phase strategies might include clearing a roadway of obstacles; maintaining a safe following distance among all vehicles in the caravan; and training all drivers in evasive maneuvers to avoid a crash. Post-event strategies might include factors such as accessibility for MEDEVAC crew, lighting for the crew, command support of MEDEVAC program, distance to field hospital, and training of the field hospital staff.

Figure 6. Haddon Matrix of Interventions to Reduce Wartime Motor-Vehicle Crashes

	Factors		
Phase	**Human (Host)**	**Equipment (Vector or Vehicle)**	**Environment**
pre-event	fatigue; familiarity with terrain and vehicle; driving experience; personality; speed; smoking; use of alcohol/drugs	ABS brakes; vehicle in good condition (e.g., lights, brakes); weight distribution to avoid rollover; good tire traction; speed capability	Terrain; weather; visibility; enemy position and disposition; reconnaissance accuracy; command enforcement of training protocol and alcohol/drug prevention; speed limit
event	use of safety belt; speed	air bags; helmets; energy-absorbing steering column; structural integrity (roll bars, side bars)	obstacle-free road; vehicle following distance
post-event	knowledge of first aid; general health; age, smoking, alcohol or drug use; prior injury history	fire retardant interior/gas tank; first aid gear on board; fire extinguisher	open terrain for rapid evacuation; command support of MEDEVAC; planning for triage; distance to field hospital; training of field hospital staff

Many of the interventions that would go in the first column (human factors) derive from models for changing individual behaviors, while most strategies listed in the second column, and some in the third column, involve engineering or structural changes that don't require specific actions by the host.

The Haddon matrix has stood the test of time and has been a useful tool in the design and implementation of injury interventions for more than 20 years, but Carol Runyan has recently proposed adding a "third dimension" or "third axis" to it (69). Once all possible ideas for interventions have been brainstormed and placed in the appropriate cells, it is useful to establish the guidelines by which you will weigh the pros and cons of each suggestion, and thus make your decisions about which interventions to develop and implement. The conceptual model of the matrix then becomes more cubelike, with the addition of these factors aligned along the top edge of one of the sides of the cube. Each of the ideas recommended in each of the cells of the matrix is then weighed by these standards in the decision about which intervention ideas get developed and implemented. For example, in designing an intervention to reduce ankle fractures among Airborne parachutists, commanders might weigh such factors as cost, efficacy, feasibility, soldier preferences, or impact on readiness. This expansion of the matrix formalizes the process of weighing the costs and benefits of the various ideas that have been suggested, and conceptualizes the decision-making process within the tool to an even greater degree.

HADDON'S 10 STRATEGIES FOR CONTROL OF HAZARDS OF ALL TYPES

The 10 strategies allow each aspect or component of an energy transfer to be analyzed separately. In essence, the 10 strategies are a multidimensional approach to discovery of the best or most practical intervention point or points. In some cases, a given strategy may suggest an intervention that is not practical, economical, or politically feasible with current technology or the political climate. Nonetheless, by considering each strategy carefully, we ensure that no stone is left unturned, and the probability of finding a viable intervention is greatly increased.

1. Prevent the Creation of the Hazard in the First Place

Figure 7. Weather Watchers Give Parachute Training the "All Clear"

Two soldiers at the Fryar drop zone at Fort Benning, GA, take measurements at a weather station. If weather conditions are hazardous, training jumps may be canceled. This illustrates Haddon's first strategy of hazard control, to prevent the creation of a hazardous situation in the first place.

Without the buildup of thermal, kinetic, or electrical energy, few high-energy hazards would exist. If we could avoid war, no one would be killed in battle. If nuclear weapons were never created, no detonation of nuclear weapons could take place. In a more basic sense, the decision not to raise babies above the floor, to lift skiers to the top of the slopes, or to put a 2,000-lb automobile in motion, also illustrate this first strategy. As the first and perhaps the most basic of the 10 strategies, it can also be the least practical from a sociopolitical standpoint. On the other hand, the military is an environment where commanders have near absolute power to dictate policy pertaining to individual and unit activities, as well as the choice of equipment and vehicles. With proper command support, safety measures that might not be possible in a civilian environment might be initiated with little debate in the military.

Examples of this strategy from the military and civilian worlds include the following:

- a ban on assault weapons
- the elimination of trampolines in secondary schools
- a ban on the production of landmines
- a policy of "safety stand down days" to ground airplanes in bad weather
- the artificial reduction of snow buildup before it reaches avalanche potential
- the discontinuation of plutonium production
- a ban on the manufacture of asbestos-containing insulation materials

2. To Reduce the Amount of the Hazard Brought into Being

The second strategy is similar to the first except that it requires only a significant reduction of a hazard, not its complete elimination. This strategy is more likely to be viable because it represents a degree of compromise. Most people are used to certain limits on their activities and will accept reasonable constraints. Many dramatic successes have come from the employment of the second strategy, such as the dramatic reduction in childhood poisoning from limiting the number of pills in a bottle, or the reduction in motor vehicle fatalities from reductions in the legal speed limit.

Figure 8. Destruction of Anti-Personnel Mines

These Marines are stacking anti-tank and anti-personnel land mines for destruction at Guantanamo Bay, Cuba. During the Cold War, more than 50,000 land mines were buried in the buffer zone separating the Marine installation from Communist Cuba; they have been replaced with motion detectors and sound sensors. This is an example of Haddon's second strategy of hazard control: to reduce the amount of the hazard that exists, especially where it already exists, or where you cannot completely eliminate it. The work these soldiers do will protect future generations of soldiers patrolling the periphery at Guantanamo Bay, but they may be placing their own safety in jeopardy because while they are wearing some Explosive Ordnance Destruction (EOD) protective gear, they are working without helmets

Examples of this strategy include the following:

- the removal or destruction of enemy chemical weapons
- the limitation of arms sales to certain nations
- substitution of alcoholic beverages with non-alcoholic or low-alcohol beer
- institution of the 55-MPH speed limit
- institution of a speed limit on base
- reduction in the speed capability of vehicles
- reduction in the lead content of paint
- lowering the height of a baby's crib
- reduction in the height of diving boards

3. To Prevent Inappropriate Release of a Hazard That Already Exists

Sometimes it may not be feasible to eliminate or even reduce the amount of a hazard that is present. The next logical step, then, is to take every step possible to prevent that hazard from being released in an inappropriate or unintentional manner. While this can be accomplished by destroying a hazard already in existence, it can also be accomplished by stopping or controlling its release, or some combination of both.

Figure 9a and 9b. Crashworthy Fuel Systems

This OH-58C helicopter crashed, but in part because these aircraft are designed with a crashworthy fuel system, both soldiers on board survived the crash. The photo on the right shows the fuel bladder, which seals upon impact, preventing fuel from spilling after a crash. Crashworthy fuel systems for helicopters have reduced postcrash fires from one of the most important causes of aviation-related deaths and injuries, and such fire-related deaths are now relatively rare events. This demonstrates Haddon's third strategy, to prevent inappropriate release of a hazard that already exists.

For example:

- addition of rumble strips at edges of highway to wake up a dozing driver before a crash occurs
- installation of barriers to prevent suicide jumpers from leaping off the Golden Gate bridge
- application of sand to icy sidewalks
- installation of electrical fuses
- installation of fences around pools
- addition of quick-release bindings on skis
- incineration of chemical weapons
- elimination of delivery vehicles of biological weapons (e.g., destroy SCUDS)
- installation of a safety device on an M-16 rifle
- destruction of laboratory stocks of deadly biological agents
- installation of window guards on floors above ground level to prevent children from falling out of windows
- use of self-sealing fuel bladders and auto shut-off fuel valves on aircraft
- application of non-skid surfaces on stairs and bathtubs

4. To Modify the Rate or Spatial Distribution of Release of the Hazard from Its Source

Figure 10. Parachute Landing Fall

The parachute-landing fall (PLF) allows the jumper to distribute the energy of landing across five separate body regions rather than one. Doing so dissipates the force of the impact over a larger area, lessening, and usually eliminating, trauma to the ankles and feet. The pack will hit the ground first, further minimizing the forces of ground impact.

Modifications that influence the rate at which the hazard is released are particularly useful in cases of mechanical energy transfers where reducing the speed of the transfer is key in determining the degree of damage caused. Human tissue can often sustain transfers of large amounts of energy if the energy transfer occurs slowly enough. For example, low-porosity parachutes decrease the velocity of descent and thus reduce the energy of ground impact. Likewise, increasing the spatial distribution of release of energy also reduces injury risk. For example, the parachute-landing fall (PLF) allows the jumper to distribute the energy of landing across five separate body regions rather than one. Doing so dissipates the force of the impact over a larger area lessening, and usually eliminating, trauma to the ankles and feet.

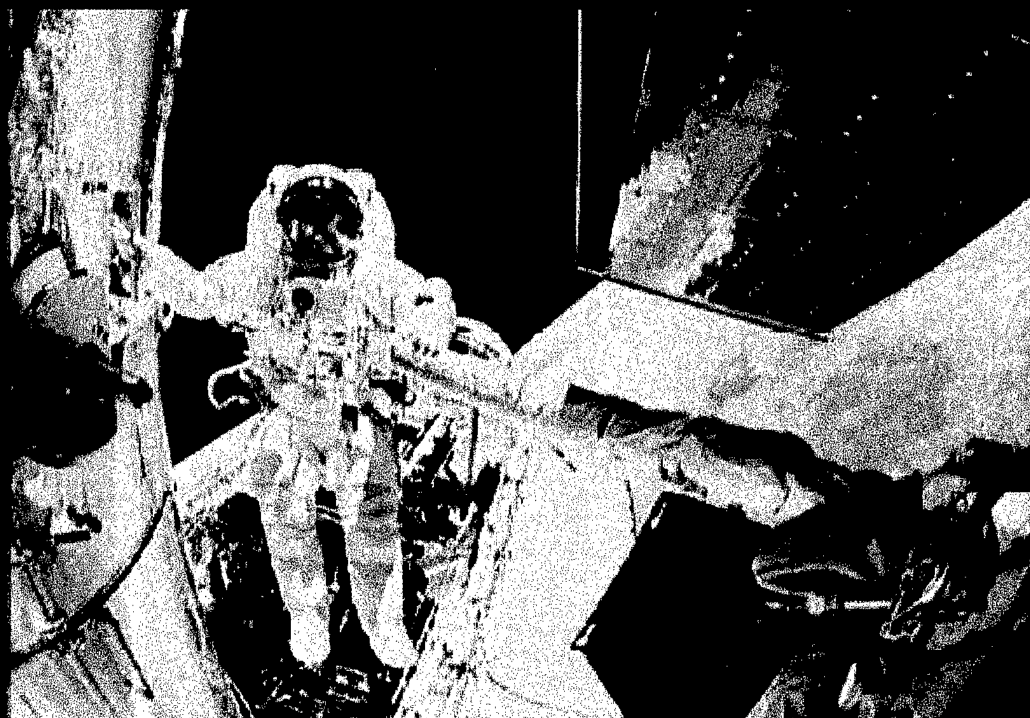
Other examples of this strategy include the following:

- antilock brakes
- airbags and seatbelts
- fire-, smoke-, or heat-activated sprinkler systems
- diver-decompression tables
- arresting gear on aircraft carriers
- selection of Space Shuttle velocity and trajectory for reentry
- control rods in nuclear reactors
- low-porosity parachutes
- Nomex flight suits (to limit thermal burns)
- placement of water barrels in front of roadside obstacles
- UH-60 Blackhawk helicopter g-force reducing seats

5. To Separate, in Time or Space, the Hazard and That Which is to be Protected

The fifth strategy essentially seeks to keep the hazard and the person from being present at the same place or time. This can be accomplished through a variety of methods, including physical and temporal phasing of transportation or work schedules.

Figure 11. EVA Spacewalk



This shuttle astronaut is participating in an extravehicular activity (EVA) spacewalk to make repairs to the Hubble space telescope. EVA spacewalks, especially during times of increased sun-spot activity, can be staged at night, to shield the astronauts from the harmful gamma and X-ray exposure of the sun's rays; a good example of Haddon's fifth strategy, to separate, in time or space, the person from the hazard. (Photo courtesy of NASA.)

Examples of this strategy include the following:

- altitude spacing of aircraft
- shipping lanes
- lightning rods
- fire escapes
- longer fuses on firecrackers
- traffic-light phasing of automobiles and pedestrians at intersections
- EVA spacewalk at night to avoid gamma and X-ray exposure
- evacuation of civilians before political upheaval in foreign nation
- transportation of hazardous waste at night when no one is around
- application of insecticides before troops arrive
- storage of hand guns in secure facility on military installations
- aircraft ejection seats to remove pilot from aircraft before the crash

6. To Separate the Hazard and That Which is to be Protected by the Interposition of a Material Barrier

Perhaps the most straightforward of the strategies, the sixth strategy has been employed successfully for centuries.

Figure 12. Protective Gear

This Air Force technician is outfitted in full protective gear as he checks the fins on a Sidewinder missile. Haddon's sixth strategy for injury prevention recommends the separation of a person from hazardous substances by a material barrier. Although such protective equipment is important in shielding soldiers from chemical and biological hazards, it may carry with it unintended consequences, in that it may encumber the soldier, limit his dexterity to accomplish certain tasks, and place him at risk of heat exhaustion.

Examples in a military context include the following:

- Kevlar helmets
- safety glasses
- torpedo nets
- antiballistic missiles
- UV-absorbent sunglasses
- electrical insulation
- SCUBA gear
- MOPP gear
- airbags in helicopters and cars
- surgical gloves
- Nomex flight suits
- steel-toed shoes
- fences around pools
- flak vests
- laser goggles
- ear plugs

7. To Modify the Relevant Basic Qualities of the Hazard

Common sense, applied to the manufacture and design of equipment, vehicles, and materials, can go a long way toward injury prevention. Two simple attributes of objects, known since the time of Hippocrates, (34) are that softness and a large radius of curvature make objects less likely to cause injury during collisions. The application of these basic engineering principles to the design of tools, toys, vehicles, and equipment can improve safety with little or no additional cost. The seventh strategy thereby focuses on the hazard itself.

Figure 13. Designed to Crash

The UH-60 Black Hawk helicopter was developed to the military's specifications in consideration of decades of crash data, and in order to maximize survivability upon impact. Its safety features include a self-sealing, crash-resistant fuel system; energy-absorbing landing gear and crew seats; and a collapsible control stick. Despite affectionately saying that the Black Hawk is "built to crash," many a thankful aviator has walked away from a devastating crash with a greater appreciation for the meaning of the word "crashworthy." Efforts to modify the hazardous elements of the vehicle and protect its occupants in the event of a crash render the Black Hawk a fine example of Haddon's seventh strategy.

A few examples of this strategy are the following:

- design of pen caps that have air channels to prevent child suffocation
- construction of ergonomic staircases
- application of non-skid surfaces
- use of rubber bullets and fire hoses instead of night sticks and firearms for riot control
- setting of phasers on stun (Star Trek)
- elimination of sharp or hard surfaces in aircraft cockpit or automobile dashboard
- installation of shock-absorbent surfaces on playgrounds
- design of a breakaway or energy-absorbing control stick in helicopter
- removal of roadside obstacles or installation of breakaway road signs
- placement of sand- or water-filled barrels at highway exit ramp
- erection of guardrail to deflect car back onto roadway rather than stopping vehicle abruptly
- use of low-voltage lighting or electrical systems where possible
- construction of double-hulled ships

8. To Make That Which is to be Protected More Resistant to Damage From the Hazard

In contrast to the seventh strategy, the eighth strategy attempts to redesign or modify the victim of injury rather than the hazard. The eighth strategy attempts to increase the strength, stamina, conditioning, or other inherent qualities of a person or his environment that will in turn make him or her better able to withstand an injury-producing event.

Figure 14. Training Exercises

Soldiers routinely undergo physical conditioning to maintain their strength and stamina. Doing so may make them better able to withstand an injury-producing event.

Some examples of this strategy include the following:

- psychological and physical conditioning of soldiers or athletes
- compartmentalization of ship so that it will not sink if the hull is breached in one compartment
- ensuring soldiers get adequate nutrition and rest (e.g., power naps)
- administration of clotting factors to hemophiliacs to prevent bleeding emergencies
- administration of appropriate vaccines to counter the effect of biologic agents
- prevention of osteoporosis through treatment with calcium, Vitamin D, and estrogen replacement
- pharmacological sleep induction on transcontinental flights
- gradual, staged ascent to altitude to ensure acclimatization before constructing camp

9. To Begin to Counter Damage Already Done by the Environmental Hazard

Most of the methods suggested by the ninth strategy are secondary rather than primary prevention efforts. The first step in this strategy is to detect damage that has already occurred or that is still occurring, and to take steps to stop the damage from continuing. Finally, this stage also initiates the recovery process. While it is generally preferable to prevent injury in the first place, rapid detection and prompt treatment of injuries can eliminate or greatly reduce their consequences. The ninth strategy may involve primary prevention in some cases, as it may prevent re-injury or development of a fatal condition among those already injured.

Figure 15. After Tragedy, Relief in Oklahoma City

These Air Force soldiers are distributing bottled water to search and rescue workers in Oklahoma City, in the aftermath of the explosion of the Murrah building. Secondary prevention measures such as this are an important example of Haddon's ninth strategy, to begin to counter damage caused by a hazard.

A few examples of this strategy are the following:

- reconstruction or restoration of bridges, hospitals, and key infrastructure sites
- activation of an emergency radio beacon on a downed aircraft
- equipping water survival gear with a radio and water-soluble dye indicator to increase likelihood of rescue
- restoration of damaged desalination plants
- rescue of shipwrecked sailors after explosion on deck
- restoration of ABC's (airway, breathing, and circulation) in basic life support
- treating a victim of CO poisoning or decompression sickness ("the bends") in a hyperbaric chamber
- development and support of a MEDEVAC program
- telemetry with higher echelons of care/telemedicine links
- water-activated beacon on a life raft
- airdrop food, water, and medicine to war-ravaged territory
- rapid first aid and evacuation for victims of injury
- splinting of broken bones

10. To Stabilize, Repair, and Rehabilitate the Object of the Damage

Once damage has occurred it is important to stabilize the victim in order to prevent further damage. The next step is to begin the process of treating the injury and facilitating rehabilitation to prevent re-injury or susceptibility to new injuries. The Air Force MEDEVAC program provides a good example of this strategy.

Figure 16. MEDEVAC Helicopter

A U.S. Army UH1H Medical Evacuation Helicopter lands on the USS New Orleans during a joint-service mass-casualty exercise held in Somalia during Operation Restore Hope. Rescue is the first step in rehabilitation and convalescence, Haddon's tenth strategy.

Other examples include the following:

- detect and respond to injuries (EMS)
- trauma centers
- burn center (BAMC facility was instrumental in treating Pope AFB crash victims)
- skin grafting
- cosmetic surgery
- rehabilitation

PASSIVE INTERVENTION STRATEGIES

Over the past few decades, there has been an increased emphasis on environmental and engineering-based injury-prevention interventions and a reduced emphasis on interventions directed at changing individual behavior. Focusing on external solutions, rather than on personal actions in injury prevention has had a twofold advantage. First, physicians and other health-care personnel who may have been discouraged in their attempts to influence the behavior of individuals have found other ways to address injury prevention in their practices. Second, researchers have discovered other opportunities to prevent injury, even when the injury-producing activity itself cannot be averted.

Passive strategies generally employ engineering and biophysical modifications to vehicles, equipment, or the environment. The principal advantage to passive strategies is that they often prevent injury regardless of human behavior, and can be quite cost effective. Because passive interventions are engineered into the environment, they usually provide their benefits without having to rely upon the memory, training, skill, sobriety, or mental state of the individuals being protected. The problem of blaming the victim can also be avoided.

ACTIVE INTERVENTION STRATEGIES

While all active strategies require an individual to consciously make a behavior choice, the approaches available to achieve this end are varied and largely determined by the particular philosophical and methodological bent of the injury-prevention specialist designing the intervention. Much research has been devoted to understanding and predicting health behavior choices. If one examines the behavior of individuals within large populations, one will observe substantial differences in the types of health behaviors in which those individuals engage. There are many reasons why these differences exist and, as a result, many different ways one might go about studying these variations and, ultimately, modifying relevant behaviors. Some of these approaches to understanding differences in health behaviors focus on factors extrinsic to the individual, and some focus on factors intrinsic to the individual (21).

Extrinsic factors that affect health behaviors include environmental regulations and legal restrictions. Environmental regulations in a civilian setting might include taxation on alcohol or subsidization for infant car seats. In a military setting examples may be found on individual bases where rewards are conferred upon units with the highest fitness scores, completion of a year without an injury fatality, or in the provision of easy access to health care. Legal restrictions are laws and regulations that ban dangerous substances or punish individuals for engaging in undesirable behavior (not using safety belts, not wearing helmets, etc.). Thus power to leverage behavior change is generally in the form of political, social, or economic sanctions and incentives. For example, while it may happen rarely, a servicemember who allows him or herself to get sunburned may be punished under Article 15 of the Uniform Code of Military Justice (UCMJ). Sailors ordered not to consume alcohol the night prior to deployment could be subjected to a Breathalyzer test and face punishment if found to be noncompliant.

Interventions that modify extrinsic factors arise primarily from deterrence theory. Deterrence theory suggests that these extrinsic factors may effectively deter one from engaging in unsafe behaviors (or as a corollary, encourage them to engage in safe behaviors) if the following holds true: 1) the individual believes he or she has a high probability of getting caught if they fail to engage in the desired behavior; 2) the person will, once caught, have a high probability of getting convicted; 3) the time between being caught and convicted is short; and 4) the punishment following conviction is severe. These elements are sometimes abbreviated as "swift, severe, and certain." (67)

Deterrent strategies essentially coerce behavior change through the leverage of power (19). The strategies may be either proscriptive or prescriptive. Proscriptive approaches include rules, laws, regulations, and incentives designed to discourage the adoption of unsafe behaviors (e.g., fines for speeding, docking of pay for unsafe behavior). For example, the military's policy of doing routine urine screening for certain illicit drugs is widely credited for the decrease in drug abuse among servicemembers since the early 1980s (14, 15). Prescriptive strategies also leverage power, but instead of discouraging unsafe behavior these approaches encourage the adoption of safe behaviors. These include safety belt laws, helmet rules, and pilot safety checklists to be used before takeoff.

There are some problems that may arise when using deterrent approaches to control injuries. First, deterrent strategies assume individuals engage in a process of rationally weighing the costs and benefits of an action before proceeding. In reality, behavior choices are influenced by other factors as well, such as the psychological and social status of the individual. The use of substances such as alcohol or drugs may also affect decision-making ability. To be completely effective, this approach also requires that an individual be capable of performing the desired behavior 100% of the time. Over-deterrence may also be a problem. It is possible to create a great enough deterrent effect that the person overcompensates (42). For example, it is wise for a soldier in a battle situation or a pilot in flight to proceed with great caution to avoid serious trouble. However, if he or she is too cautious in using life-preserving efforts vital missions may never be accomplished. Some element of risk taking is necessary. Deterrent approaches are somewhat retrospective in that for deterrence to work the individual has to first engage in the behavior. Individuals are punished after the behavior has already hurt them. Finally, the ability to consistently enforce policies in a manner that is "swift, severe, and certain" is often hampered by limited resources and discretionary behavior of those called to the task of enforcement (48, 68). Also, the development of laws and regulations occur through the political process, or through a level of command that may be influenced more by concerns over constituents or broad military objectives than by reductions in key risky behaviors (47).

Intrinsic factors affecting behavior choices include demographic characteristics (e.g., gender, age, and race) personality traits, social support, social networks, and cognition. There are behavioral theories arising out of each of these intrinsic factors. However, since most of these elements are intractable (i.e., one can't change a person's gender or age), it seems most prudent to focus on cognition as a predictor and motivator of health behavior choices. In addition, cognition is important in predicting how an individual will react to extrinsic factors.

Cognition comprises the thought processes that occur between experiencing a stimulus and making a behavior choice in various situations (21). It is how individuals make sense of the world given a situation and the information they already possess—including beliefs, attitudes, and knowledge the individual maintains about a particular health behavior.

Several models, all broadly described as social-cognitive, have been developed to assist in understanding and predicting health behavior choices. Each model holds certain assumptions about human nature. Intervention strategies derive from the particular model believed to be valid or useful in predicting a particular health behavior decision. Like deterrent theory, social-cognitive models also assume a person will engage in a process where they rationally weigh costs and benefits of a behavior and then make a choice. Instead of focusing on the nature of those costs and benefits, however (as the deterrence models do), social-cognitive models focus on how people interpret costs and benefits and how they perceive their environment and then use this information to make health-related behavior choices. Interventions then derive from these models. Once a behavior is understood, efforts can be made to alter the perceived value or cost of an action in order to change behavior.

While there are many social-cognitive models—more than can be fully discussed in the context of this chapter,—a few of the more common models are particularly salient to this discussion and worth a quick review.

THE HEALTH BELIEF MODEL

This is one of the oldest of the social-cognitive models and has been moderately useful in predicting actual health behaviors. This model focuses on how perceptions of a threat to one's well being influence beliefs and behaviors that are associated with that threat. This model would suggest that in order to motivate an individual to change his or her risky behavior, that person must first believe that engaging in a certain behavior makes it likely that he or she will experience an injury *and* the injury must be viewed as serious. Behavior alternatives are selected based upon the person's awareness of behavior options, beliefs about the efficacy of those alternative behaviors and perceptions about the costs (or barriers) to engaging in the new behavior (12). Cues to action, such as education efforts that suggest new behavior choices, are also often included in this model.

Examples of injury-prevention efforts that derive from this model include programs geared towards the modification of risk perceptions (e.g., education about the importance of helmets while parachuting, posters that remind sailors of the risks involved in drinking before or during SCUBA diving). Such programs may also attempt to change perceptions about the benefits of adopting a new health behavior, reduce barriers to changing behaviors and provide cues to action (e.g., a pilot check sheet). Thus, most efforts that are designed to provide a soldier, sailor, airman, or marine with additional information (e.g., educational campaigns) come from the Health Belief Model.

When health-care practitioners endeavor to prevent or reduce injuries, it often seems that the first intervention plan they develop involves educating those at risk. While there are some situations where education is useful in preventing injuries, there are some significant limitations to this approach. First, some key cognitive variables are missing that are useful in predicting health behavior decision making. Social and peer pressure are not taken into account (except as a modifier of perceived risk of injury). Peer groups may have an enormous influence on risk taking particularly in certain settings. Self-efficacy, or beliefs about how much control one has over a behavior, are not included in the Health Belief Model, or in general education campaigns. In injury prevention terms this might mean that a person believes injuries are the result of random events and not something to be controlled or avoided. He or she may believe that seatbelts are uncomfortable or that they even increase risk and thus be unwilling to buckle up. When the risky behavior in question includes use of alcohol or drugs, there may be a physical inability to control the behavior without some form of medical intervention.

HEALTH LOCUS OF CONTROL

Related to self-efficacy is the notion of locus of control. Health Locus of Control is an important axiom in the whole health promotion field. In essence it describes an individual's sense about how much he or she controls or influences his or her own health and well being. There are three possible beliefs an individual can have about their control over their own health: internal control, external control with a belief in powerful others, and external control with a belief in fate. Internal control means an individual believes they are in control of their health and can affect their health status through their behavior choices. Those who subscribe to external control with a belief in powerful others believe they have little control over their health status but that others, such as doctors, spouse, nurses, etc., can affect their health. External control with a belief in fate means that the individual believes they have little control over their health status and that injuries and illnesses are a result of fate or acts of God (75). The association between a person's sense of control over his or her health is strengthened when the relative value they place on their health is also included (21). Interventions deriving from the Health Locus of Control arena strive to increase perceptions individuals hold about their control over their health and well being. For example, fitness programs may be enhanced when individuals are also counseled about the effectiveness of this effort in achieving overall good health. A program that documents improvement in health (e.g., reduced blood pressure, lower weight, better lung capacity, less foot pain or low back pain) also may facilitate a sense of control over health and well being. An individual with a belief in external powers might be encouraged to adopt safer behaviors if a respected person (e.g., physician, commander, etc.) suggests this.

SOCIAL LEARNING THEORY

Many commonly employed social-cognitive models are based on or draw on key components from Bandura's social learning theory (10). Social Learning Theory suggests that a person's perception of control (self-efficacy) and environmental controls and incentives interact to affect the adoption of health behaviors. A person is most likely to engage in safe behaviors if he or she thinks choosing the safe behavior (over an unsafe action) will result in positive reinforcement (e.g., better health, positive feedback from important others such as friends and family) and if that reinforcement has value to the individual. The Theory of Reasoned Action is closely related to this model.

THEORY OF REASONED ACTION

This model focuses on an individual's attitudes about a particular safe (or unsafe) behavior, as well as the social context in which he or she engages in the behavior. Like Social Learning Theory, this model recognizes that peer and social groups are important elements in making behavior choices. This model also focuses on intentions to behave in a given manner. (I.e., is the person motivated to adopt the safe behavior, or does he or she have a conscious plan in place for how he or she will behave?) Attitudes about the safe behavior are also important (e.g., does the individual enjoy exercising and maintaining physical fitness?) and have an impact on the likelihood of actually performing the behavior because they directly affect intention to behave. Attitudes are developed not just out of thinking about the relative enjoyment (or costs) of a behavior but also out of subjective norms (e.g., what will people think of me if I wear safety goggles and protective gear?) and how much one values the opinions of others.

Interventions that incorporate tenets from Social Learning Theory and the Theory of Reasoned Action focus on peer groups and norms. Examples in the civilian world include campaigns such as the "Friends Don't Let Friends Drive Drunk" media effort. The military environment is perhaps particularly well suited for development of these sorts of interventions since much emphasis is placed on teamwork, camaraderie, and caring for each other. Examples include having a buddy check camouflage before a maneuver; or restricting privileges for a whole group if one member does not comply with a safety rule; or giving the whole unit a 4-day pass if there are no motor vehicle-related injuries in a set period of time. While no one in the unit would admit to valuing a four-day pass more than life, awareness of motor vehicle safety is heightened as the end of the time period nears and the likelihood of obtaining the award may become a powerful motivator.

STAGE MODELS

Stage models suggest that there are different cognitive stages, or thought processes that are important at different stages in the development of a health behavior. One of the most well-known stages models was developed by Prochaska and DiClemente (transtheoretical model of change) to understand and predict addictive behaviors (26, 62-64). It has now been widely applied to other health behaviors including some injury-associated risk-taking behaviors such as alcohol use, smoking, and exercise. In this model individuals are seen progressing through a series of stages on their way to adopting a new, desirable health-related behavior. There are six stages of change in this model. In the precontemplative stage, the individual is unaware that an existing behavior is risky. In the contemplative stage, the individual becomes aware of the risks related to his or her behavior. At the preparation stage, he or she begins preparing to change the risky behavior. The action stage is when the person begins putting intentions to change into action. In the maintenance stage, he or she establishes and supports the continuance of this new behavior. Often there is also a relapse stage when a person reverts back to the old unsafe behavior and then must cycle through some or all of the stages again in order to re-acquire the new safe behavior. Decisional balance is a key component of stage models. Intervention efforts, developed around an individual's stage of readiness to change behavior, are designed to help tip the balance towards moving on to the next stage.

It is important to ascertain an individual's or a community's level of readiness in order to design an intervention appropriately. Individuals or communities in precontemplative stages require interventions that focus on making them aware of the risks of their current behaviors and supporting thoughts about the desirability and feasibility of a new, alternative healthy behavior. Individuals and communities who are moving towards the preparation and action phase don't need educational campaigns telling them of the dangers of their current behavior. They need assistance in developing a plan for changing their behavior. Those who have already adopted a new, safe behavior (in the action/maintenance phase) require intervention efforts that support their efforts and provide feedback to them on how well they are doing in achieving their expected goals.

Though the stage models focus on active behavior change strategies, it is worthwhile to note that they are not exclusively focused at changing behavior at the level of the individual. Often the creation of new regulations (e.g., legislation) or some procurement of resources is needed in order to develop and implement an injury prevention program. This requires that a commander or perhaps many people in a chain of command take action. Before a commander will implement a policy, he or she must see the need for it (precontemplative), decide to act (contemplative), implement a policy (action), and provide resources to maintain the system (maintenance). For example, the command at Fort Bragg was initially briefed about the high rate of ankle injuries associated with the Airborne operations. Reviewing this information made them aware of the scope of the injury problem associated with this particular type of injury, and moved them from the precontemplative to contemplative stage. After reviewing the data about ankle injuries among Airborne soldiers, they granted permission to a team of researchers to pilot-test an ankle brace designed to prevent such injuries. The data the researchers gathered demonstrated a significant reduction in ankle injuries when the ankle brace was used. After reviewing data about the efficacy of the brace, the command moved into the action stage. Ankle braces then became routine equipment for students in the Airborne school at Fort Benning and were made available to essentially all Airborne soldiers in the Army. After it was implemented, the operational Airborne community fell into the relapse stage, as new leadership began to question the efficacy of the brace and to focus on unfounded fears that the brace might cause proximal injuries. Data from a new evaluation study of the ankle brace might help support this intervention and move the Airborne community from the relapse stage back into the action stage.

SOCIAL CONTAGION MODEL

This model is derived from the study of infectious disease. It suggests that behaviors, like disease, may be thought of as contagious if an individual is more likely to engage in that behavior when a significant other has already done so. In many ways, this model is similar to Social Learning Theory. The model also, however, postulates that contagion will cause an increase in the prevalence of a behavior as the size of the population that engages in that behavior increases. The model has been shown to have some use in predicting behaviors such as teen promiscuity, drug abuse, binge eating, suicide, and driver speeding. For example, a driver's decision to speed is only partly predicted by his or her demographic background, attitudes towards speeding (Theory of Reasoned Action), beliefs about the consequences of speeding (Social Learning Theory and Health Belief Model) and police efforts to enforce speed restrictions (Deterrence Theory). The remaining variation in speeding behavior may be dependent, at least in part, on the behaviors of drivers around the individual at a given point in time (e.g., "Yes, officer, but I was just driving fast enough to keep up with the rest of the traffic.") (22).

Models of health behavior have some utility in predicting the choices that individuals make about their own safety. However, they are all limited in that they require an individual to be capable of engaging in a particular behavior (i.e., they require rational thought and the physical and mental ability to make behavior changes). These approaches are limited, because some injuries are caused by other individuals, and because humans are simply not capable of operating at 100% effectiveness 100% of the time. (They sometimes make mistakes or are in situations that limit behavior choices.) For example, if one is driving a car and a young child runs out in the road, and another car is oncoming in the other lane and there is a tree on the other side of the road, what is the best behavioral choice? Human behavior is motivated by a multitude of factors, some of which are not amenable to change through intervention, or at least not easily changed (e.g., culture, peer influence, addiction, income, education).

MANAGEMENT OF INJURIES IN THE FIELD AND ACCESS TO CARE

In the final section of this chapter we provide a new approach to the organization of wartime battle-related injury prevention. The proposed model incorporates some of the unique characteristics of war environments in the development of injury control approaches.

Comprehensive injury prevention programs attempt not only to prevent or reduce the severity of injuries, but also to provide a plan for management of injuries when they do occur. Access to care may pose a major barrier to the effective management of injuries in the field. While the purpose of this chapter is not to provide great detail on combat casualty care, injury control covers the full spectrum of care from prevention to rehabilitation. A brief discussion of the care and management of the injured is therefore warranted.

Management of injury in the field will be greatly influenced by the availability, accessibility, accommodation, affordability, and acceptability of medical care services (61). Limits to any one of these 5 areas may prevent an individual from receiving needed care. Availability refers to whether or not needed services are present in quantities sufficient enough to meet demands. Accessibility describes whether or not those in need of the service are able to get to the distribution site. Accommodation indicates whether or not the service is presented in such a way as to meet the special needs of the target population. Affordability describes whether those needing the service possess adequate resources to obtain the service. Finally, acceptability describes perceptions of those receiving and administering the service and whether or not the service is provided in a way that is agreeable to all parties.

The principal goals of injury management in the field should be to stabilize the individual, take steps to minimize long-term consequences of the injury, and facilitate the rapid return of the individual to as normal a level of functioning as possible. Three distinct phases in the management of field injuries may be identified: short-range or immediate needs, medium-range care, and long-range care and rehabilitation. Access to care is important at all levels or phases of injury management.

Short-range Management of Injury

Short-range management refers to what happens in the time interval immediately after the injury has occurred. During this time the victim must be stabilized and transported to treatment if necessary. The following components of access to care must be considered in planning for short-range field management of injury:

1) Availability. Does the service exist (e.g., are MEDEVACs or trained medical technicians in the area)? Does it exist in quantities sufficient to meet the demand (e.g., are there enough UH-60 Blackhawk helicopters to pick up all those who are seriously injured in a particular area)? Injury mortality and morbidity are related to the types of injuries incurred on the battlefield and the proximity and sophistication of available medical care. Experience in past conflicts, for example, has shown that putting physicians at or near the front lines helps reduce injury deaths (27).
2) Accessibility. Can the injured person be readily picked up or can the injured person easily reach the treatment center? What sort of assistance will he or she require in order to get to the facility? Factors that affect accessibility include the terrain or vegetation where the injured person is located, the number of non-injured soldiers available to assist in evacuation, presence of enemy fire and backup friendly fire, distance to the MEDEVAC crew, and distance to the hospital or treatment center.
3) Accommodation. Are the resources available for the injured person sufficient to meet his or her needs? Factors that influence accommodation include the severity of the injury, the presence of co-morbidities or other factors that might reduce the ability to stabilize the victim for transport. Training factors include training the MEDEVAC crews in how to stabilize the injury and training other soldiers in the unit to assist with treatment of the individual. Finally medical

resources must be available to stabilize and treat the injured person (e.g., the MEDEVAC helicopter must be adequately equipped).

Medium-range Management of Injury

Medium-range management of injuries involves the medical treatment and short-term rehabilitative efforts to save the injured person's life, reduce adverse sequelae, and improve functioning. The following components of access must be considered:

1) Availability. Is there an adequate treatment facility available for the injured person and is it close enough to the site of the injury event? Administrators must accurately estimate number of field hospitals needed in a particular area and must have alternate plans in place to accommodate overflow at other installations. The field hospital must have enough beds, surgical rooms, and emergency supplies and services.
2) Accessibility. Can the injured person reach the care facility quickly? The proximity of the field or shipboard hospital to the battle area as well as the availability of MEDEVAC resources, presence of helicopter landing pads or ambulance-accessible roadways, availability and ability of staff to transport and triage patients are of prime importance. The facility itself must be located so that it is safe from enemy fire and strategically located away from flood plains, etc.
3) Accommodation. Are services sufficient to meet patients' needs? It is essential for the medical treatment staff to be adequately trained and experienced to handle the specific level (severity) of injuries they will encounter and there must be enough staff at the site. The staff must have the ability to link up with other facilities and experts. The severity of injuries encountered by soldiers in the field influences accommodation as well as the general state of the individual upon arrival. Their state upon arrival depends not just on the severity and type of injury they have sustained, but also on their physical fitness and health habits (smoking, alcohol use, illness history, sleep, and nutritional status) and on how well they were stabilized and managed in the field and during transport.

Long-range Management of Injury

Long-term management of injury is related to the ability to manage and support longer rehabilitation, necessary for treating some types of injuries, and to facilitate recovery of function and independence. Several elements affect this ability, including adequate facilities (staffing and resources) to provide for the physical and mental recovery and rehabilitation of injured soldiers, sailors, and airmen. A comprehensive program will also include counseling and training for the development of new life skills and/or occupational skills to facilitate return to work in some capacity. There should be social workers or counselors available to facilitate re-integration into military jobs or the civilian sector. Medical advocates need to assist injured military personnel in understanding benefits and options available to them, including transfers to different health care systems (e.g., out of field hospitals into Veteran's Administration hospitals or other facilities). The achievements and sacrifices of the injured soldier, sailor, or airmen must never be overlooked. Follow-up is needed to continue monitoring the recovery process and document the progress of re-integration. The latent development of physical or mental problems related to injury and the re-integration process must also be monitored, and morbidity and mortality among veterans and reservists no longer on active duty must be followed. Finally, long-range planning should include incentive programs for disabled members of the armed forces to adopt a healthy lifestyle such as smoking cessation programs and programs to prevent and treat substance abuse. Efforts should be made to encourage the maintenance of physical fitness, as well as appropriate nutrition, rest, and mental health.

CONCLUSION

Injuries are a preventable public health problem. Prevention strategies are best developed when the full spectrum of injury events (pre-event, event, and post-event) is considered and when each element of the epidemiologic triangle is considered (agent, host, environment, and vehicle). Using Haddon's 10 strategies and the Haddon matrix will help insure that a comprehensive list of intervention alternatives is developed. While medical officers are in a unique position to prevent injury on an individual case-by-case basis through the care and education of patients and the training of clinic personnel, they may have even greater influence in injury prevention through their influence on those in command. They can accomplish this by acquiring knowledge of injury patterns, problems, and costs, and by applying common sense and the injury-prevention principles outlined here. Success depends upon presentation of viable options at the appropriate command level.

REFERENCES

1. Haddon Matrix: Eliminating The Mumbo Jumbo. Insurance Institute for Highway Safety.
2. American Public Health Association. NHTSA to allow airbag on-off switches. The Nation's Health, December 1997; pp. 5-6.
3. American Public Health Association. Policy statement 9311: a ban on antipersonnel land mines. Am J Public Health, 84(3):519-520, 1994.
4. Amoroso, P., K. Reynolds, and N. Bell. Benzodiazepine use and crash risk in older patients. JAMA, 279:113-115, 1998.
5. Amoroso, P.J., N.S. Bell, and B.H. Jones. Injury among female and male army parachutists. Aviat Space Environ Med, 68(11):1006-1011, 1997.
6. Amoroso, P.J., K.L. Reynolds, J.A. Barnes, and D.J. White. Tobacco and injury: an annotated bibliography. USARIEM Technical Report TN 96-1, February1996.
7. Anderson, E. and W. Talley. Alcohol involvement in recreational boating: implications for safety regulations. Applied Economics, 25:1233-1243, 1993.
8. Baker, S.P., B. O'Neill, M.J. Ginsburg, and L. Guohua. The Injury Fact Book, 2nd Edition. Oxford Press, New York, 1992.
9. Baker, S.P., B. O'Neill, W. Haddon, and W.B. Long. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma, 14(3):187-196, 1974.
10. Bandura, A. The self and mechanisms of agency. In: Psychological Perspectives on the Self, J. Suls (Ed.). Erlbaum, Hillsdale, NJ, 1982, pp. 3-39.
11. Becker, B., R. Woolard, T.D. Nirenberg, A. Minugh, R. Longabaugh, and P.R. Clifford. Alcohol use among subcritically injured emergency department patients. Acad Emerg Med, 2(9):784-790, 1995.
12. Becker, M. The Health Belief Model and Personal Health Behavior. Charles B. Slack, Inc., Thorofare, New Jersey, 1974.
13. Bell, N.S., P.J. Amoroso, and S.P. Baker. Injury control part I: understanding injuries in the military environment. USARIEM Technical Note TN XX-XX, In press.
14. Bray, R.M., L.A. Kroutil, S.C. Wheeless, et al. 1995 Department of Defense Survey of Health Related Behaviors Among Military Personnel. Research Triangle Institute, Research Triangle Park NC, 1995.
15. Bray, R.M., R.P. Sanches, M.L. Ornstein, et al. 1998 Department of Defense Survey of Health Related Behaviors Among Military Personnel. Research Triangle Institute, Research Triangle Park NC, 1998.
16. Brotman, S., M.C. Indeck, D. Leonard, and J. Huber. The study of the relationship between lifestyle characteristic self-reported drinking patterns and trauma. Am Surg, 61(11):975-979, 1995.
17. Centers for Disease Control and Prevention. National drunk and drugged driving prevention month -- December 1993. MMWR Morb Mortal Wkly Rep, 42(47):905, 1993.
18. Cherpitel, C.J., T. Tam, L. Midanik, R. Caetano, and T. Greenfield. Alcohol and non-fatal injury in the U.S. general population: a risk function analysis. Accid Anal Prev, 27(5):651-661, 1995.
19. Chin, R. and K. Benne. General strategies for effective change in human systems. In: The Planning of Change, W. Bennis (Ed.). Hold, Rinehart and Winston, Inc., New York, NY, 1969, pp. 32-59.
20. Chipman, M.L. Risk factors for injury: similarities and differences for traffic crashes and other causes. Accid Anal Prev, 27(5):699-706, 1995.
21. Conner, M., and P. Norman (Eds.). Predicting Health Behavior. Open University Press: Buckingham Palace, 1996.

22. Connolly, T. and L. Aberg. Some contagion models of speeding. Accid Anal Prev, 25(1):57-66, 1993.

23. Corrigan, J.D. Substance abuse as a mediating factor in outcome from traumatic brain injury. Arch Phys Med Rehabil, 76(4):302-309, 1995.

24. Curtin, D., J. Syner, and M. Vegega. Alcohol involvement in pedestrian fatalities -- United States, 1982-1992. JAMA, 270(16):1916, 1993.

25. Dawson, D.A. Heavy drinking and the risk of occupational injury. Accid Anal Prev, 26(5):655-665, 1994.

26. DiClemente, C.C., J.O. Prochaska, S.K. Fairhurst, W.F. Velicer, M.M. Velasquez, and J.S. Rossi. The process of smoking cessation: an analysis of precontemplation, contemplation, and preparation stages of change. J Consult Clin Psychol, 59(2):295-304, 1991.

27. Doley, E. Wartime trauma: lessons and perspectives. In: Anesthesia for Trauma, R. Kirby and D. Brown (Eds.). Little, Brown and Company, Boston, MA, 1997, pp. 191-203.

28. Fleming, M.F. and K.L. Barry. A three-sample test of a masked alcohol screening questionnaire. Alcohol, 26(1):81-91, 1991.

29. Flightfax: Army Aviation Risk-Management Information. U.S. Army Safety Center. Fort Rucker, AL, December 1997.

30. Fuller, M.G. Alcohol use and injury severity in trauma patients. J Addict Dis, 14(1):47-54, 1995.

31. Gabella, B., K.L. Reiner, R.E. Hoffman, M. Cook, and L. Stallones. Relationship of helmet use and head injuries among motorcycle crash victims in El Paso County, Colorado, 1989-1990. Accid Anal Prev, 27(3):363-369, 1995.

32. Haddon, W. The basic strategies for reducing damage from hazards of all kinds. Hazard Prevention, (Sept/Oct):8-12, 1980.

33. Haddon, W. and S. Baker. Injury Control. In: Preventive and Community Medicine, B. McMahoned (Ed.). Little Brown, 1981, pp. 109-140.

34. Haddon, W. Energy damage and the ten countermeasure strategies. J Trauma, 13(4):321-331, 1973.

35. Haddon, W. and S. Baker. Conversations from the 1970s.

36. Hallel, T. and L. Naggan. Parachuting injuries: a retrospective study of 83,718 jumps. J Trauma, 15(1):14-19, 1975.

37. Hingson, R. and J. Howland. Alcohol and non-traffic unintended injuries. Addiction, 88(7):877-883, 1993.

38. Hollands, C.M., F.K. Winston, P.W. Stafford, and S.J. Shochat. Severe head injury caused by airbag deployment. J Trauma, 41(5):920-922, 1996.

39. Howland, J. and R. Hingson. Alcohol as a risk factor for drownings: a review of the literature (1950-1985). Accid Anal Prev, 20(1):19-25, 1988.

40. Howland, J., R. Hingson, T.W. Mangione, N. Bell, and S. Bak. Why are most drowning victims men? Sex differences in aquatic skills and behaviors. Am J Public Health, 86(1):93-96, 1996.

41. Howland, J., T. Mangione, R. Hingson, G. Smith, and N. Bell. Alcohol as a risk factor for drowning and other aquatic injuries. In: Drug and Alcohol Abuse Reviews, R. Watson (Ed.). Humana Press Inc., Totowa, NJ, 1995.

42. Huber, P. and R. Litan (Eds.). The Liability Maze: The Impact Of Liability Law on Safety and Innovation. The Brookings Institute: Washington, D.C., 1991.

43. Institute of Medicine. Injury in America: A Continuing Public Health Problem. National Academy Press, Washington, D.C., 1985.

44. Kragh, J.F., Jr., B.H. Jones, P.J. Amoroso, and R.D. Heekin. Parachuting injuries among Army Rangers: a prospective survey of an elite airborne battalion. Mil Med, 161(7):416-419, 1996.

45. Laitinen, K. and M. Valimaki. Alcohol and bone. Calcif Tissue Int, 49 Suppl:S70-73, 1991.

46. Lincoln, A.E., G.S. Smith, P.J. Amoroso, and N.S. Bell. The effects of cigarette smoking on musculoskeletal-related disability. Med Sci Sports Exer, In press.

47. Lowenstein, S.R., J. Koziol-McLain, G. Satterfield, and M. Orleans. Facts versus values: why legislators vote against injury control laws. J Trauma, 35(5):786-792, 1993.

48. Lynxweiller, J., N. Shover, and D.A. Clelland. The organization and impact of inspector discretion in a regulatory bureaucracy. Social Problems, 30(4):425-436, 1983.

49. Mackersie, R.C., J.W. Davis, D.B. Hoyt, T. Holbrook, and S.R. Shackford. High-risk behavior and the public burden for funding the costs of acute injury. Arch Surg, 130(8):844-849, 1995.

50. Madson, R. A study of parachute landing injuries and their relationship to parachute performance and landing conditions. In: Survival and Flight Equipment Association. Yoncalla, OR: Survival and Flight Equipment Association, 1975, p. 77-80.

51. Mantak, F.J. Creating an alternative framework for preventing rape: applying Haddon's injury prevention strategies. J Public Health Policy, 16(1):13-28, 1995.

52. McGill, V., A. Kowal-Vern, S.G. Fisher, S. Kahn, and R.L. Gamelli. The impact of substance use on mortality and morbidity from thermal injury. J Trauma, 38(6):931-934, 1995.

53. McKinlay, J. A case for refocusing upstream: the political economy of illness. American Heart Association.

54. Merrill, J., G. Milner, J. Owens, and A. Vale. Alcohol and attempted suicide. Br J Addict, 87(1):83-89, 1992.

55. Nahum, A.M. and A.W. Siegel. The changing panorama of collision injury. Surg Gynecol Obstet, 133(5):783-791, 1971.

56. Napolitano, L.M., M.J. Koruda, K. Zimmerman, K. McCowan, J. Chang, and A.A. Meyer. Chronic ethanol intake and burn injury: evidence for synergistic alteration in gut and immune integrity. J Trauma, 38(2):198-207, 1995.

57. National Center for Health Statistics. Alcohol and drug related visits to hospital emergency departments. National hospital ambulatory medical care survey, 1994, p. 1-16.

58. National Committee for Injury Prevention and Control. Injury Prevention: Meeting the Challenge. Oxford University Press, New York, NY, 1989.

59. O'Hare, T. Alcohol consumption and presenting problems in an out-patient mental health clinic. Addict Behav, 18(1):57-65, 1993.

60. Ord, R.A. and R.M. Benian. Baseball bat injuries to the maxillofacial region caused by assault. J Oral Maxillofac Surg, 53(5):514-517, 1995.

61. Penchansky, R. and J.W. Thomas. The concept of access: definition and relationship to consumer satisfaction. Med Care, 19(2):127-140, 1981.

62. Prochaska, J. and C. DiClemente. The Transtheoretical Approach: Crossing Traditional Boundaries of Change. J. Irwin, Homewood, IL, 1984.

63. Prochaska, J.O. and C.C. DiClemente. Stages and processes of self-change of smoking: toward an integrative model of change. J Consult Clin Psychol, 51(3):390-395, 1983.

64. Prochaska, J.O., C.C. DiClemente, and J.C. Norcross. In search of how people change. Applications to addictive behaviors. Am Psychol, 47(9):1102-1114, 1992.

65. Robertson, L.S. Injury Epidemiology. Oxford Press, New York, NY, 1992.

66. Rosenberg, M.L. and J.S. Mercy. Assaultive violence. In: Violence in America, M.L. Rosenberg and M.A. Fenley (Eds.). Oxford University Press, New York, 1991.

67. Ross, H.L. Deterring the drinking driver. In: Legal Policy and Social Control. D.C. Heath, Lexington, MA, 1982.

68. Ross, H.L. and J. Foley. Judicial disobedience of the mandate to imprison drunk drivers. Law & Society Review, 21(2):315-323, 1987.

69. Runyan, C.W. Using the Haddon matrix: introducing the third dimension. Inj Prev, 4(4):302-307, 1998.

70. Smith, G.S. and J.F. Kraus. Alcohol and residential, recreational, and occupational injuries: a review of the epidemiologic evidence. Annu Rev Public Health, 9:99-121, 1988.

71. Spaite, D.W., E.A. Criss, D.J. Weist, T.D. Valenzuela, D. Judkins, and H.W. Meislin. A prospective investigation of the impact of alcohol consumption on helmet use, injury severity, medical resource utilization, and health care costs in bicycle-related trauma. J Trauma, 38(2):287-290, 1995.

72. Thompson, D.C., F.P. Rivara, R.S. Thompson, P.M. Salzberg, M.E. Wolf, and D.C. Pearson. Use of behavioral risk factor surveys to predict alcohol-related motor vehicle events. Am J Prev Med, 9(4):224-230, 1993.

73. Vingilis, E., G. Stoduto, M.S. Macartney-Filgate, C.B. Liban, and B.A. McLellan. Psychosocial characteristics of alcohol-involved and nonalcohol-involved seriously injured drivers. Accid Anal Prev, 26(2):195-206, 1994.

74. Waller, J.A., J.M. Skelly, and J.H. Davis. Treatment charges, payment sources, and disability from alcohol-related trauma. J Trauma, 39(5):963-967, 1995.

75. Wallston, K. and B. Wallston. Health locus of control scales. In: Research with the Locus of Control Construct, H. Lefcourt (Ed.). Academic Press, New York, NY, 1981, pp. 189-243.

76. Watson, W.A. and J.C. Garriott. Alcohol and motorcycle riders: a comparison of motorcycle and car/truck DWIs. Vet Hum Toxicol, 34(3):213-215, 1992.

77. Webb, G.R., S. Redman, D.J. Hennrikus, G.R. Kelman, R.W. Gibberd, and R.W. Sanson-Fisher. The relationships between high-risk and problem drinking and the occurrence of work injuries and related absences. J Stud Alcohol, 55(4):434-446, 1994.

78. Wechsler, H. and N. Isaac. 'Binge' drinkers at Massachusetts colleges. Prevalence, drinking style, time trends, and associated problems. JAMA, 267(21):2929-2931, 1992.

79. Yelon, J.A., N. Harrigan, and J.T. Evans. Bicycle trauma: a five-year experience. Am Surg, 61(3):202-205, 1995.

80. Zink, B.J. and P.J. Feustel. Effects of ethanol on respiratory function in traumatic brain injury. J Neurosurg, 82(5):822-828, 1995.